Big Idea 3
Part D: Mechanisms of Information Transfer

AP Biology

Mrs. Petrov

Part 1

DNA Transfer

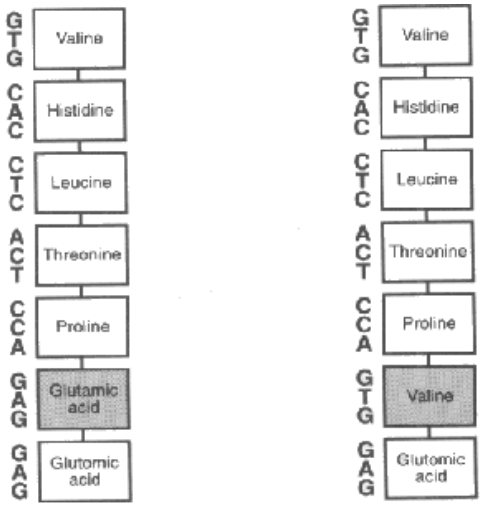
I. DNA Changes

- WHY does DNA change?
  - Errors in replication
  - Errors in repair mechanism
  - Radiation
  - Reactive chemicals
- HOW does DNA change?
  - Single base (A to G)
  - Additions/Deletions/ Inversions/ Translocation of entire sequences
  - Entire chromosome deleted/added

Mutations

a. Substitutions: **Replace** 1 base with a **different** one.

Sickle Cell Anemia
- Hemoglobin

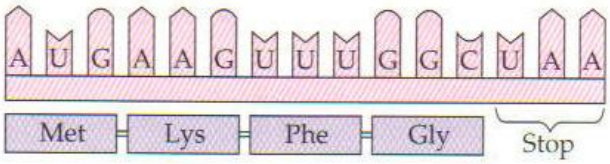


Mutations

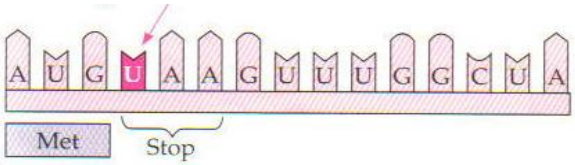
b. Insertions: **Add** a base or codon.

Muscular Dystrophy (Dystrophin)

Original



Result

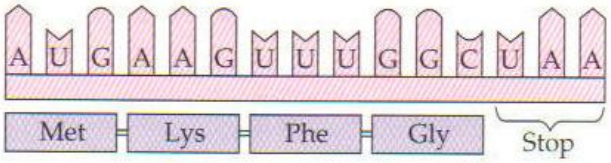


Mutations

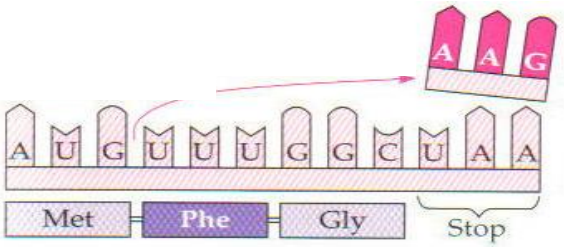
c. Deletions: **Remove** entire **codon**.

Prader-Willi Syndrome

Original

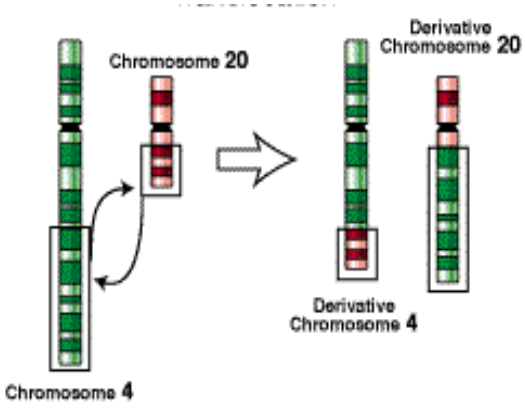


Result 1



Mutations

d. Translocation: **Part** of one **breaks** off and **attaches** to another. (MEIOSIS)



Good, Bad, or Neutral?

- The phenotypic result of a mutation depends on the environment.
- Some mutations will lead to new, favorable traits.
- Other mutations will lead to bad, deadly traits.
- And still others will have no effect.

- In the end, mutations are the PRIMARY source of genetic variation for NS to “choose” from.

II. Genomes Change

- DNA can be acquired or changed around by various mechanisms. Leads to a new organism "code"

Plasmids

Circular pieces of DNA in bacteria

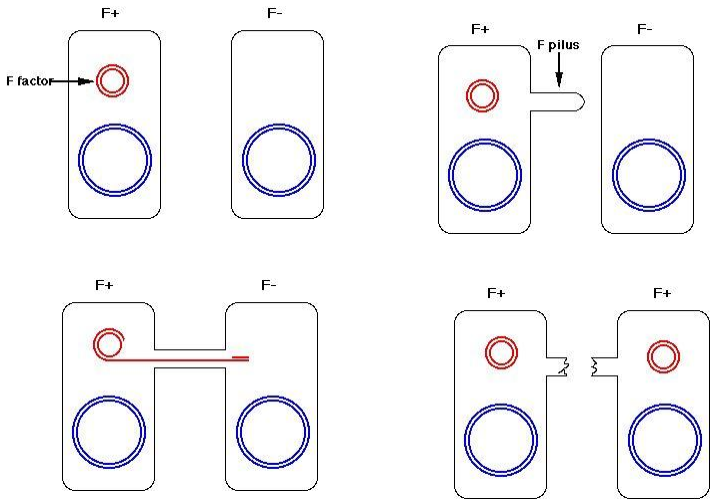
Exist and replicate independently of genome.

Not essential for bacteria.

Conjugation

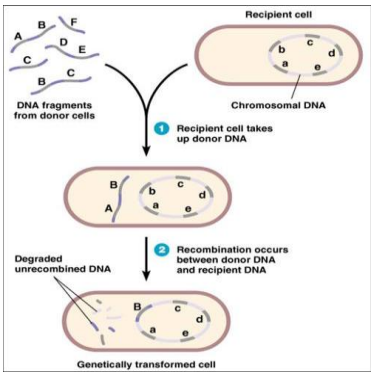
- Discovered in 1947 by Lederberg and Tatum
- **Definition**: A plasmid or other DNA element is transferred from one cell to another through direct contact (one-way).
- **Donor**: Cell that provides genetic material
- **Recipient:** Cell that receives genetic material

Conjugation Process



Transformation

Transformation: A cell **takes in** DNA from **outside** the cell. This **new** DNA becomes **part** of the cell's DNA.



Natural Transformation

- Only some bacteria can take up free DNA naturally:
  - Genetic exchange
  - DNA repair
  - DNA as food
- Survival of the Fittest!

Viruses Transfer DNA!!!

- This is called **TRANSDUCTION**
- Many viral infections involve a virus inserting ITS DNA into the HOST'S DNA, thus changing the host genome.
- Otherwise, the viral DNA may remain in the body, perhaps taken up later on.

Virus Categories

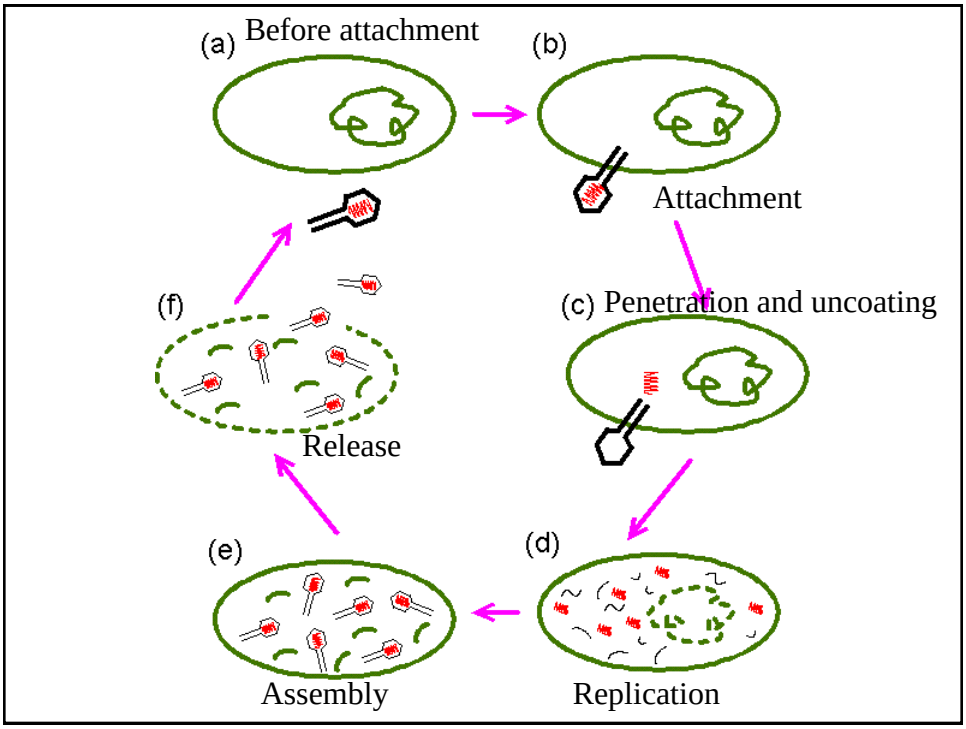
- DNA viruses – stable, do not mutate rapidly
  - Single-stranded or double-stranded
  - Smallpox, Hepatitis B
- RNA viruses – mutate rapidly, unstable
  - ***No error-checking mechanisms***
  - Single-stranded or double-stranded
  - HIV, Rhinovirus

Making New Viruses

- Can only reproduce **inside** a host cell!
- Process of reproduction = Lytic Cycle / Lysogenic Cycle

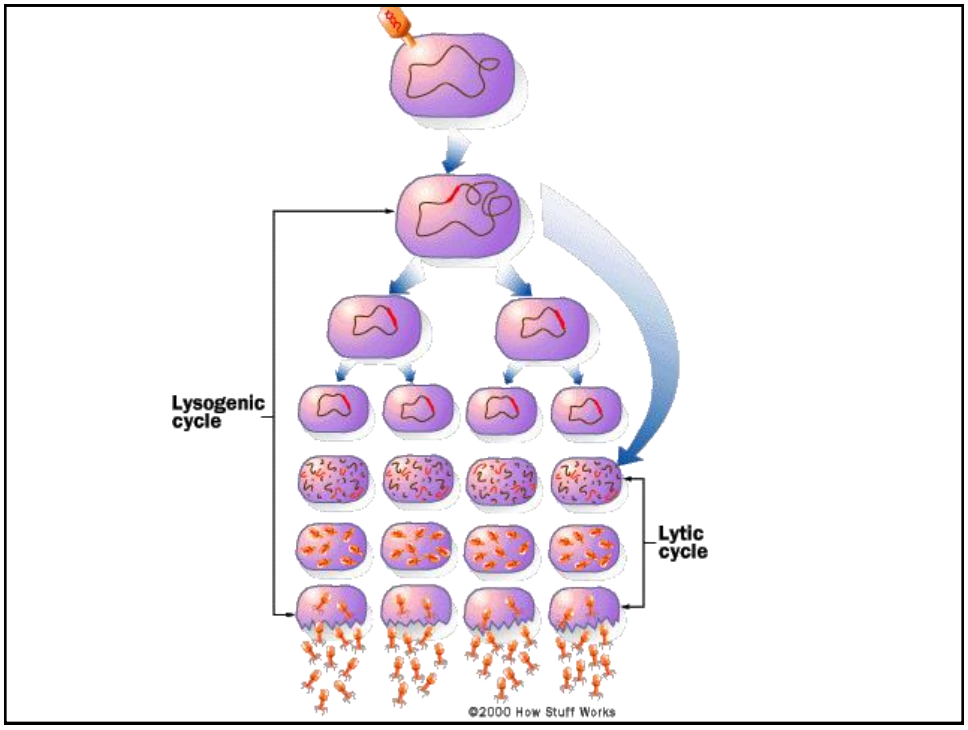
Lytic Cycle

- Virus attaches to host cell's membrane and injects its nucleic acid (N.A.)into the host cell.
- The viral nucleic acid **takes over protein synthesis,** creating new viruses.
- The host cell bursts, lyses, releasing the newly formed viruses.



Lysogenic Infection

- The virus injects its N.A. into a cell.
- The virus N.A. **attaches** to the cell's DNA
- The combined N.A. will **replicate** many times.
- The virus N.A. begins the **lytic** infection cycle.



Part 2

Transfer Pathways

Communication

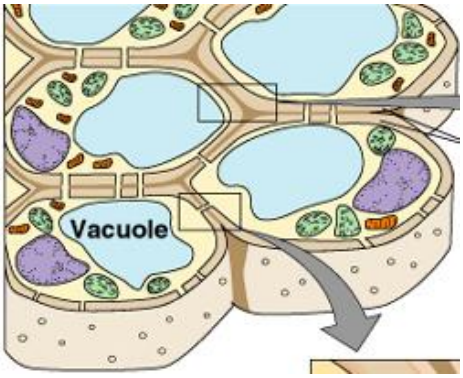
- Requires transduction of signals from the environment, other cells or other organisms.
- Under **strong** selective pressure
  - Ex. Failure to communicate your needs for nutrients leads to death!

Organism Variation

- Unicellular Organisms: Signaling **pathways** influence responses to environment
  - Quorum sensing
- Multicellular Organisms: Signaling pathways coordinate activities in cells that ultimately support the organisms' functionality.
  - Epinephrine stimulates breakdown of large sugars to fuel the body systems.

Strategies

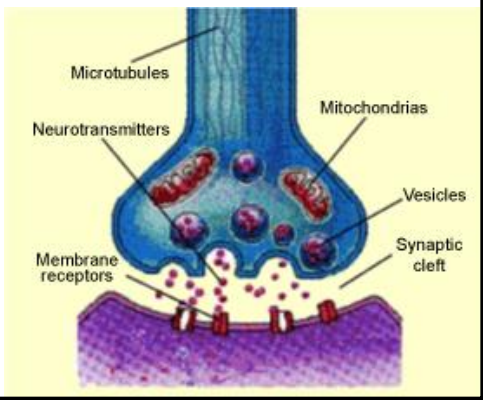
1. Cell-Cell direct contact
   – Plasmodesmata in Plants



Strategies

2. Short Distances

- Use “local regulators” targeting nearby cells.
  – Neurotransmitters
  – Transcription Factors

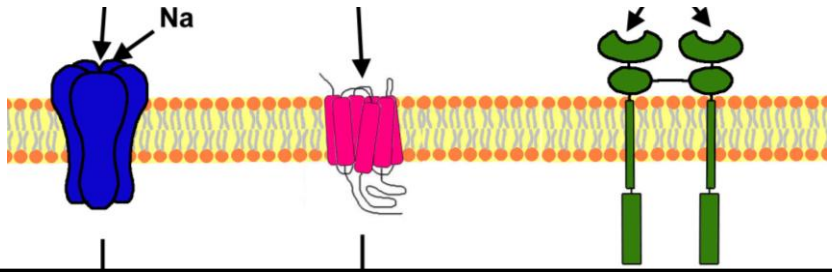


Strategies

3. Long Distances
   - **Endocrine signals (HORMONES)**
   - Specific and travel in bloodstream
   - Testosterone, Inulin, Estrogen, Thyroid hormones

Signal Transduction Pathways

- Link signal reception with the specific response.
- Different receptors recognize different chemical messengers
  - Small chemicals (N.O., small proteins, lipids)



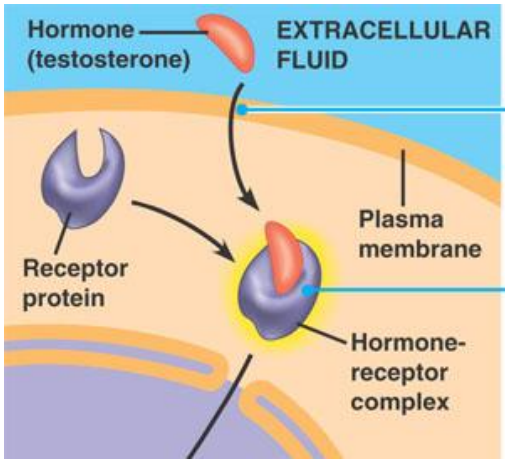
Steps

1. **Reception**: Cell receives a signal (internal or external)
2. **Transduction**: Signal is transmitted to appropriate location
3. **Response**: Signal causes a response to be generated

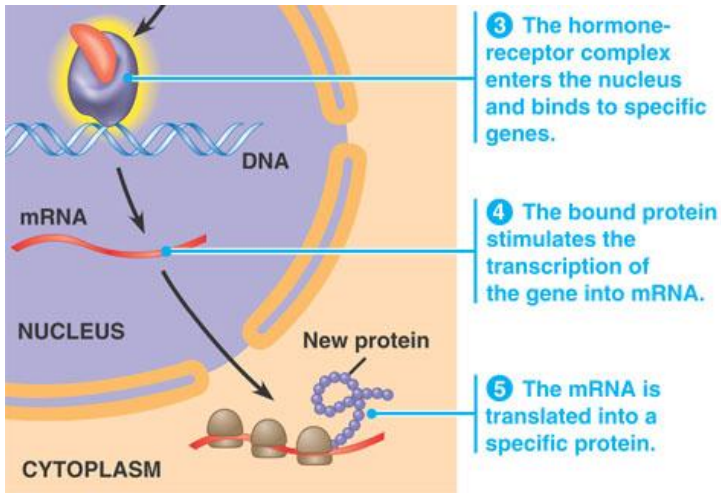
Reception

- A signal binds to a receptor. This signal molecule is called a **ligand**.
- Receptor can be in the **cytoplasm** or on the **membrane**.
- Cytoplasmic receptor activities:
  - Enzyme activation/deactivation
  - Transcription activation

Intracellular Receptors

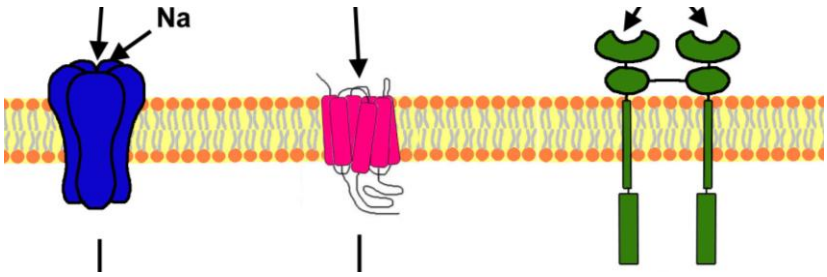


Intracellular Receptors

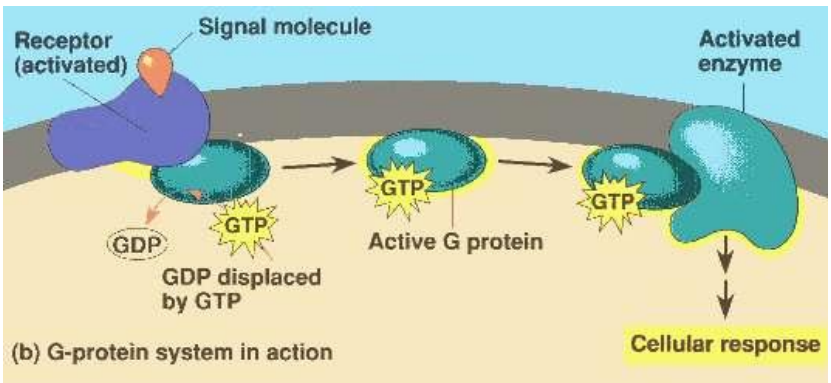


Membrane Receptors

- How can a signal cause a change in the cell without going inside the cell???
- Membrane reception relies heavily upon **integral proteins**.



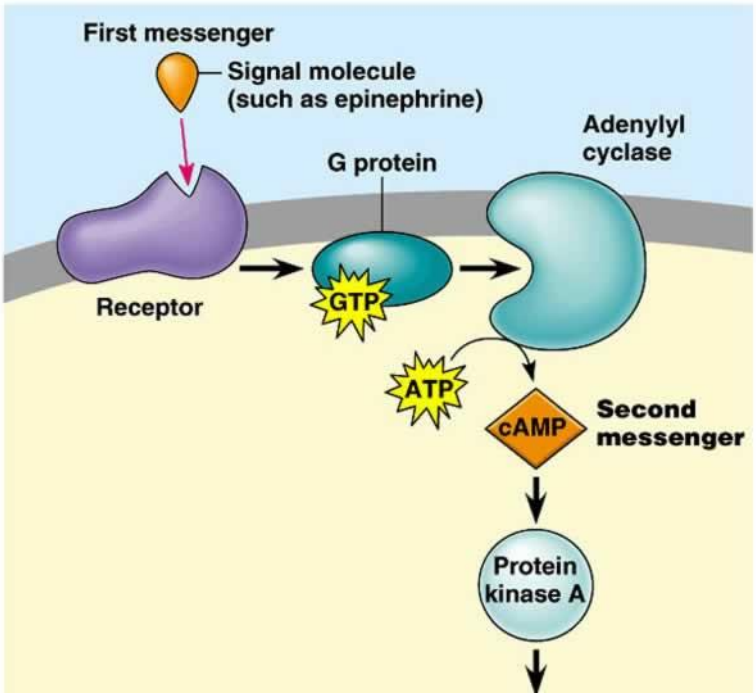
G-Protein Linked Receptors

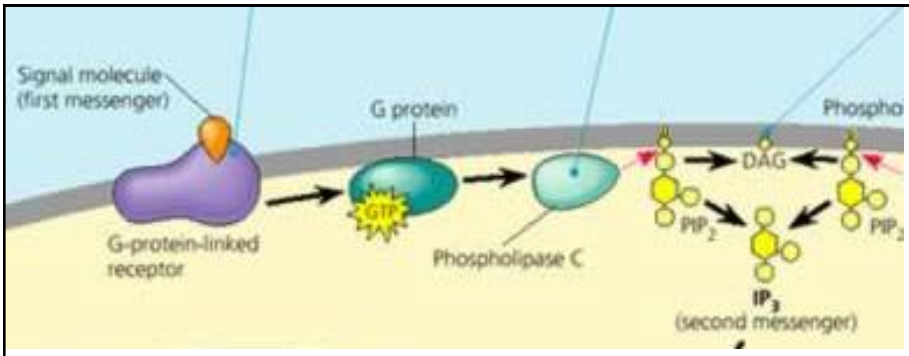


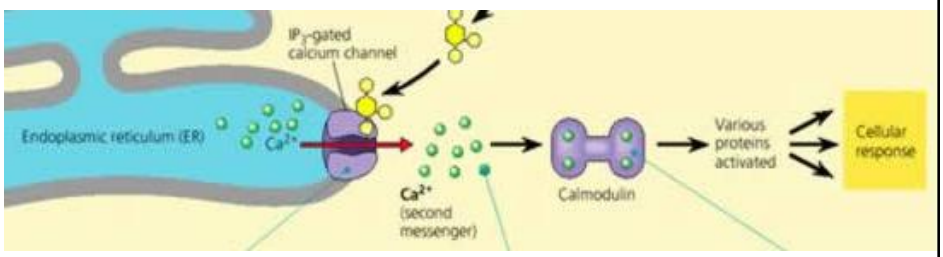
1. Ligand **attaches** to receptor binding site.
2. Causes a G-protein to **bind** and exchange GDP for **GTP**.
3. GTP **activates** the G-protein.
4. G-protein **slides** along the membrane to reach an enzyme.
5. Enzyme is **activated**, carrying out the response.
6. Eventually, the GTP **dissociates** and the G-protein is **deactivated**.

Second Messenger Molecules

- Can be essential to pathway: act as relay molecules.
- cAMP
- IP_3
- Calcium

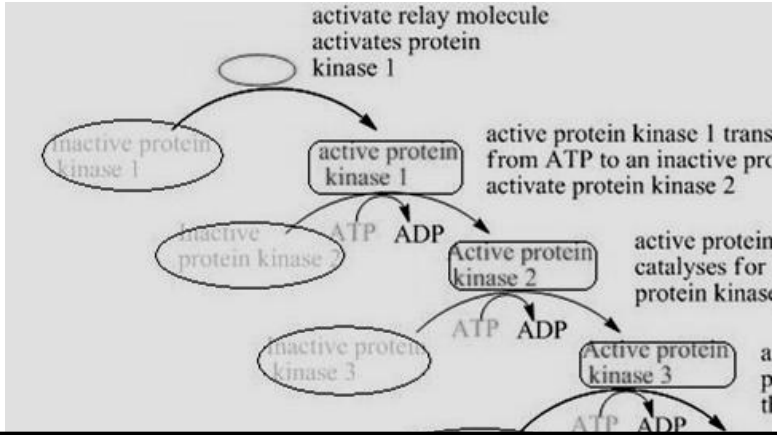

First messenger
Signal molecule
(such as epinephrine)
Adenylyl
cyclase
G protein
Receptor
GTP
ATP
cAMP
Second
messenger
Protein
kinase A


Signal molecule
(first messenger)
G protein
DAG
G-protein-linked
receptor
GTP
Phospholipase C
IP3
(second messenger)


IP3-gated
calcium channel
Endoplasmic reticulum (ER)
Ca2+
Ca2+
(second
messenger)
Calmodulin
Various
proteins
activated
Cellular
response

Phosphorylation Cascades

- ATP activates kinases…which activate other things.



Defects in Pathways…

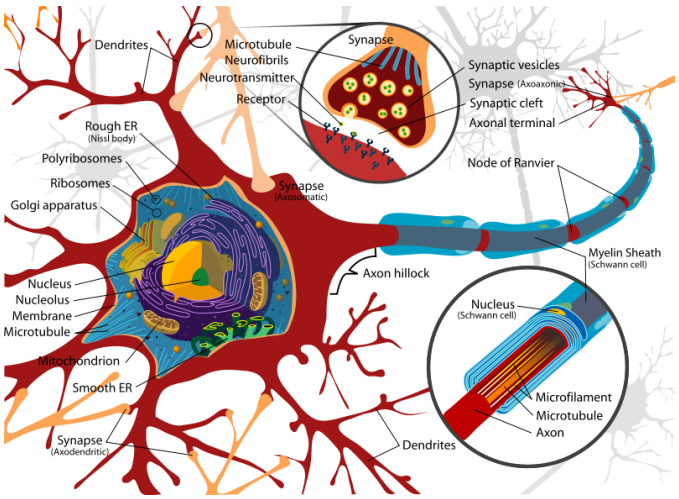
- Diabetes (genetic)
- Neurotoxin effects (chemical)
- Drugs (chemical)

Part 3

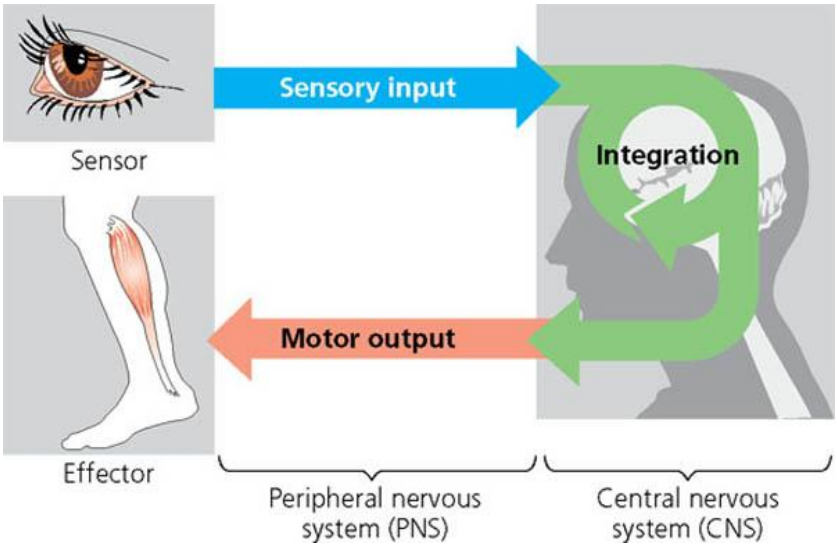
The Nervous System

The Nervous System

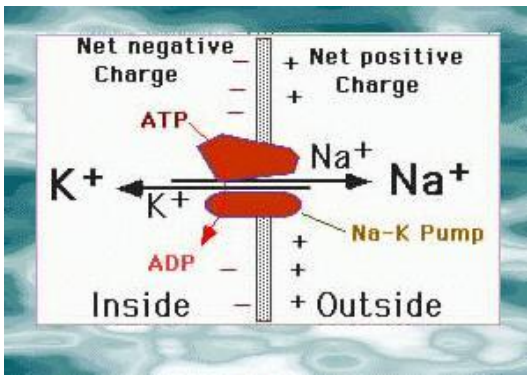
- The basic unit for signal transduction is the neuron.



Responses



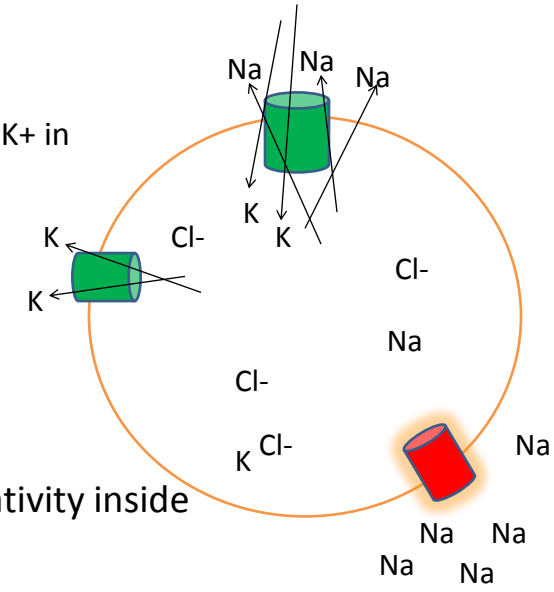
Before A Stimulus



- Cells have more negative charge inside than outside
- Resting membrane potential -70mV
- No signaling
- Powered by ATP

Before A Stimulus

- Na+/K+ Pump
  - 3 Na+ OUT for 2 K+ in
    - Less + inside
    - More - inside
- Na Channels
  - CLOSED
    - No + Influx
- K Channels
  - Some open
    - Slight + Eflux
- Cl increases negativity inside

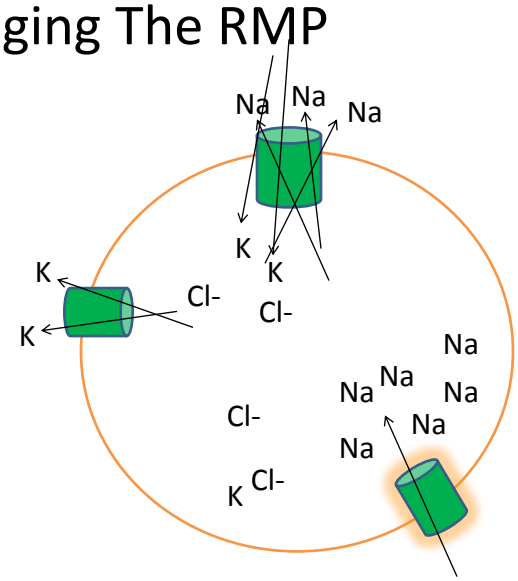


Stimulus Sensed

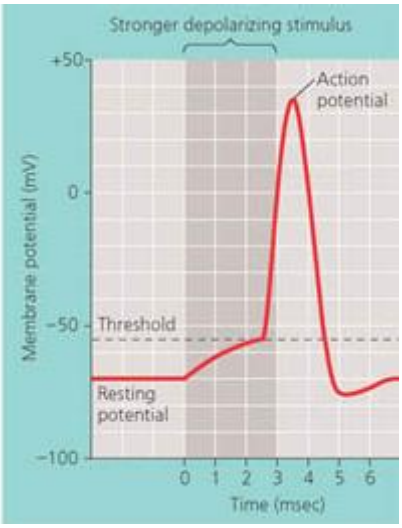
- Sensory Transduction
  - Initiates a change in RMP
    - Hunger
    - Pain
    - Light
    - Temperature
    - Chemicals
  - Change in the RMP = Receptor Potential
  - Open ion channels & depolarize membrane

Changing The RMP

- Na Channels
  - OPEN
- Causes RAPID influx of Na
- Makes inside suddenly more POSITIVE
- Depolarization



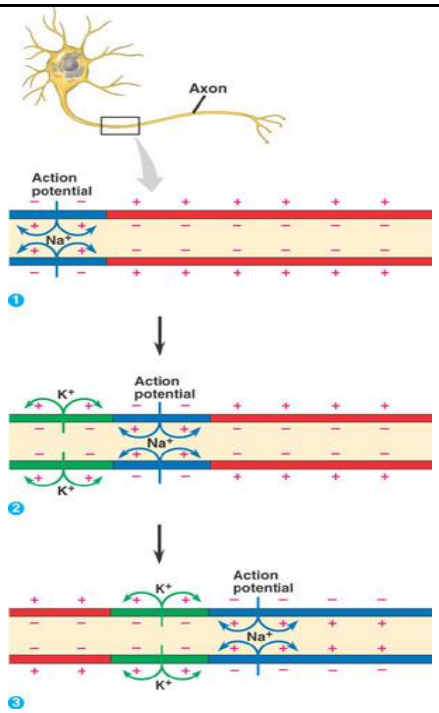
Action Potential



- Stimuli cause depolarization
  - Inside of nerve becomes positive
  - Outside becomes negative
- Signal = Magnetic Resonance Energy
- MRI's produce images based on your nervous system's signaling processes

Transmission

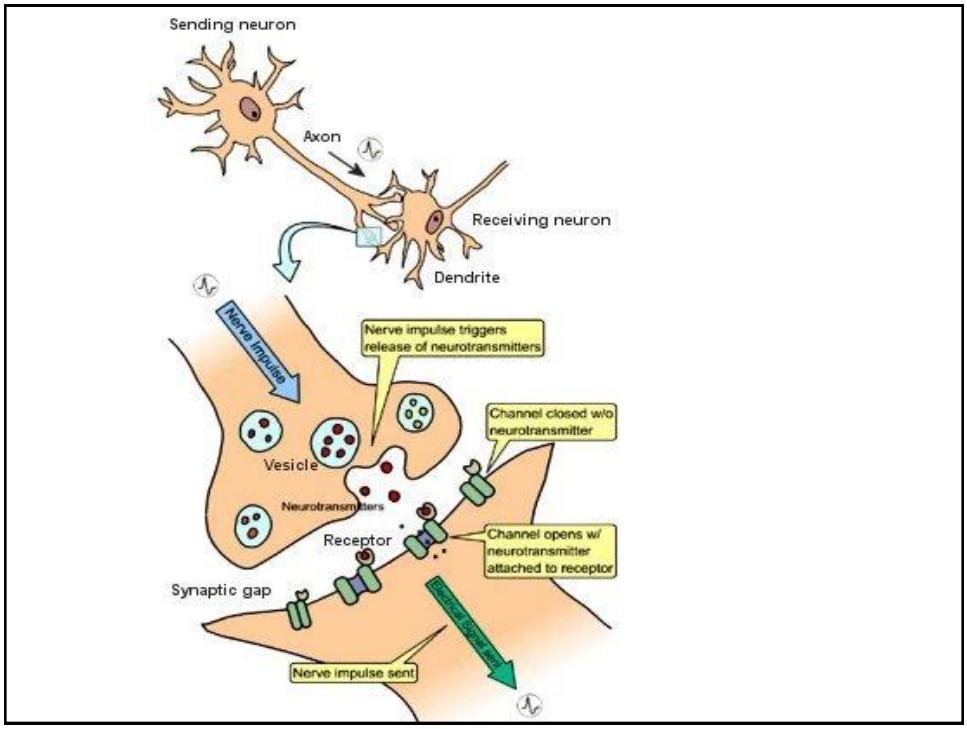
- Strength of 1st depolarization causes continuous depolarizations along the nerve
- Propogation



Neurotransmitters

Transmit the signal across synapses

- Acetylcholine
- Epinephrine
- Dopamine
- Seratonin
- GABA


Sending neuron
Axon
Receiving neuron
Dendrite
Nerve impulse
Nerve impulse triggers release of neurotransmitters
Channel closed w/o neurotransmitter
Vesicle
Neurotransmitters
Receptor
Channel opens w/ neurotransmitter attached to receptor
Synaptic gap
Nerve impulse sent